USDA FOREST SERVICE: STREAM VELOCITY MEASURING DEVICE

STREAM TEAM: COLE BAILEY, JOSHUA CAMPER, ANTHONY DESANTIS, MAX RIETZE

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Executive Summary

Develop Bluetooth technology for wireless communication two or more conductivity probes that can be used to measure small stream velocity. There are three main reasons that this project was necessary, and they are:

1. To update a system that has been used in USDA stream studies for about 20 years.
2. To create a safer (more ergonomic and trip free) working environment for field researchers.
3. To support a more efficient data collection by using modern handheld devices, doing the math for the user, and saving results more securely.

Background

The motivation for this work is to update an old system that has been used for around 20 years. It uses an old laptop, so they must always keep a battery/generator with them to keep the laptop charged and powered on. This makes the old system heavy, awkward, and difficult to use. The old system has lengths of wire that can get hooked up on tree branches and brush. This can make it unsafe to use as the user may be liable to tripping over the exposed wires.

The opportunity associated with this project is to update this old system to be much more practical with today's technology. It will be much smaller and easier to carry for long distances and will no longer need a laptop and battery chargers as it will just connect to any smartphone or

tablet. This new design will also be much safer since it will be wireless, so you will not have any lengths of wire that you can trip over or get tangled up in.

Problem Definition

Our goals and restraints for this project are as follows:

- OPERATING ENVIRONMENT
    - Work in a wide variety of stream velocities (0 to 10 m/s)
    - Work with a wide variety of steam widths (A couple inches to several feet across)
    - Have a probe separation of about 6 stream widths.
    - Use conductivity probes to measure the velocity.
- USER FRIENDLINESS
    - Remote operation – wireless system that can read as far as 100 ft.
    - Versatile probe support – may be used by operator for balance in rough terrain.
    - Display – data available to user on smartphones or tablets
    - Set up – device can be up and running within 20 minutes.
    - Transportability – can be easily carried ¼ mile by one person (less than 20 lbs.)
    - Packaging – all components fit within a single waterproof carrying case.
- DURABILITY
    - Must be suitable for use in all weather conditions, including rain/sleet/snow.
    - Streams can be full of sediment that can interrupt testing.
    - Can break in such a way that the device pollutes the environment.
    - Batteries can support field operation for at least 10 hours with no recharging.
- SOFTWARE

- Velocity calculation – probe separation divided by time between peak-to-peak concentrations.
- Reliability – calculations with 5% error or less
- Data logging – DAQ that runs on batteries equipped with an Excel-like tool.
- Sample rate – 8 reading/sec with simultaneous sampling from two channels

Project Plan

The team roles and responsibilities that we decided on are:

- COLE BAILEY
  - Probe circuit design
  - App design
- JOSHUA CAMPER
  - Probe circuit design
  - Wiki Master
- ANTHONY DESANTIS
  - Probe housing design
  - Budget
- MAX RIETZE
  - Probe housing design
  - Team documentation

Our planned schedule can be seen in a Gantt chart in the appendix. The first item on our schedule was to make sure the probes that we were using would be able to accurately measure the concentration of salt in the water and communicate this between both probes. We wanted to have

this done by the end of September. The next thing we wanted to start working on was making the app and making sure it could read the data from the probes. We initially wanted to have this done early in the first semester, but we did not get all the bugs ironed out until the end of the second semester.

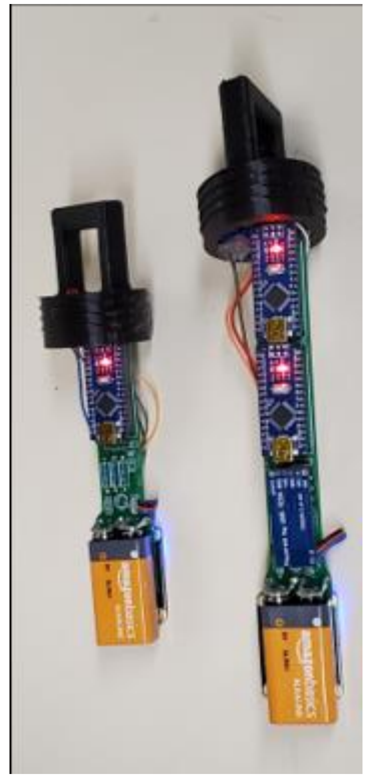
We then wanted to start the housing design that would work on all stream sizes. We needed to have the initial circuitry done fast so that we could do work on the housing. Once the housing was finished, we were to test the waterproofing. If everything went well, we were also planning to do some real-world testing when the snow melted in the spring. Unfortunately, we were not able to finish in time to do this.

There were a couple of setbacks we encountered in our design process that changed our schedule. The first being that our clients wanted to have a PCB when we were not initially planning to get one made. This set us back a couple of weeks for the housing design since we did not know exactly what size the PCBs would be. The next thing that ended up setting us back was out plan for the excess wire in the housing. We initially wanted it to be bunched up in the excess space, but this did not work for several reason. We ended up working on this problem until we ran out of time and were unfortunately not able to produce a satisfactory solution. This made it so we did not have a final prototype done until late in the second semester and threw our plans of real world testing out the window.

To see the full schedule, see appendix 3.0.

Conceptual Design

Circuit



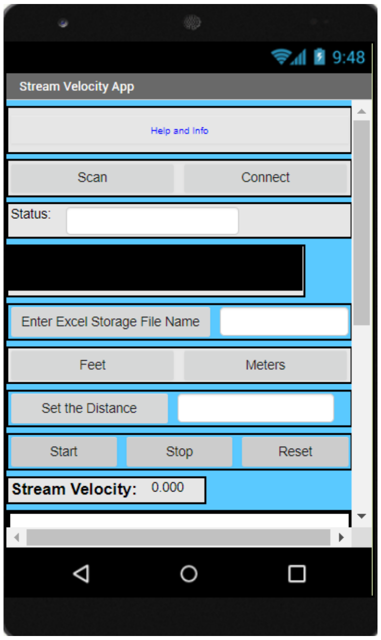
Our initial circuit design used two Arduino Nanos, one HC-06 Bluetooth module, and two HC-12 wireless antennas. In this design the secondary Nano would send its data to the primary Nano, where the primary Nano would then send the data of both probes to the smart device through the Bluetooth connection. This design failed because the Arduino Nanos can only read and write from one serial connection at a time and our primary Nano was using two serial modules (HC-06 Bluetooth and the HC-12 wireless communication). We also planned on having two LEDs in this design, one to indicate when the circuit was powered on, and one to indicate when the circuit had low battery.

In our second design we added a sub-primary Nano to the primary Nano. The purpose of this was to just have the sub-primary communicate with the secondary, and the primary only communicate with the smart device. This allowed us to send both probe's data to the smart device with almost no time delay due to the I2C connected between the primary and sub-primary Nanos. Also in this design, we updated the HC-06 Bluetooth module to an HM-10 Bluetooth module as the HC-06 would not be able to connect to newer devices as its Bluetooth was becoming outdated. In this design, we went from two LED's to just one since we had to change our initial buttons to buttons that would constantly be powered on with a single press of the button. We were able to reduce the number of LED's because our new buttons had a built in LED that we could use to indicate when the circuit was powered on.

The final thing to do with the circuitry was to make a custom PCB to solder all the components on. Our design for the PCB needed to be plug and play along with everything else in the design. To do this we planned on making the PCB with pin headers so all the components could be unplugged if needed, and new ones could just be plugged back in. This would make the design much more compact and get rid of any excess wiring that could be broken off while the probe is being used.

User interface

To create a user interface for the electronics we decided to build an App using a free online app builder called MIT App Inventor. The reason we chose this inventor was due to its compatibility with Arduino Electronics, and due to its simplistic design tools which allows more unexperienced app builders, such as us, to design complex apps. To begin the design, we started building code around the basic requirements the app needed to accomplish. These included receiving/sending incoming data to/from the sensors, have a live graph of that incoming data, be able to store the data from each test, and to run multiple tests in a row. With these basic requirements we started first with coding a connection between the HC-06 and the app since this was our first Bluetooth Module. Next, we created a text box to enter in the Excel File name we wanted to save our data in, a textbox to enter in the distance needed to calculate velocity, three buttons to start, stop, and reset the electronics, a textbox to show the final velocity calculated on the Primary Arduino, two textboxes for the incoming sensor values, and a live graph to show the data in real time. This concluded our first iteration of the app design during the first semester.



However, we still had problems with the live graph, data storage in excel, and displaying the senor values.

Then after various presentations, testing days, and a reconfiguration of the Electronics Design we were able to gather more requirements for the design. The largest challenge of which was changing from the HC-06 to the HM-10 Bluetooth module. This change allowed us to include IOS and have Bluetooth 4.0. However, converting the app to be able to even connect to this module was a larger problem than expected. The solution to which included doubling the code and uploading external files into the MIT App Inventor which allowed use to use the HM-10. Even so, after we were connected, we had a long trail of troubleshooting and debugging to be able to successfully receive and send data. Once this connection problem was solved, we were able to restore functionality to the Excel File storage, live graph, final velocity, and sensor values. Next, we added in the various suggestions from our clients such as a differently formatting the excel file differently and an option to change between meters and feet. The ending design is pictured above, and functionality is as follows: Scan for the HM-10, select and connect to it, enter in the desired excel file name, choose the measurement system needed, enter in your measured distance between each probe, and then press the start button to begin the test, stop once the test has concluded, and reset if a new distance is wanted. All the while the data is simultaneously being live graphed and stored into Excel. Thus concluded our User Interface development.

Probe development

Our probe housing development took a linear path from initial concept to final design. The full drawing package is included in Appendix 2.1. We knew for the housing to be able to adapt to various stream sizes it would have to be able to extend and contract. For large streams, the device can reach a max length of 6' and for smaller streams a pin can be removed allowing it to be easier to reduce the overall weight when it is not needed. The pin also serves to attach a wrist strap so that the user may not accidentally drop the probe into the stream for it be washed away.

We still had to ensure that on the off chance the probe was submerged the circuitry would not be damaged. To do this we laser cut disks out of acrylic and glued them into the bottom then used sealant to ensure that water would not be able to seep through. This however is a permanent seal. Since the probe runs on batteries, we had to have a way to access the board. Our solution was to instead of purchasing a threaded cap we 3D printed our own so that we could ensure a very tight fit and to allow us to add the button and lights mentioned above. After initial testing we found we would need an O-ring to ensure a waterproof seal at the bottom of the threads.

As far as the durability of the house is concerned, we decided that metal would be too heavy, and that schedule 80 PVC would be thick enough to endure the loads that it would see on their worst day. Other contributing factors to our decision to select PVC is that it is cheap and easy to alter. This allows for easy adaptation to future models. Another thing that we needed consider was the drag force that would be experienced by the tubing that was in the water. To reduce this as much as possible we used the thinnest PVC, we could that would still allow the probe to run through it.

We found that this would be 1/2” PVC. We would also need 1” for the ½” section to retract into. Then using a reducer, we connect a our 1” extension piece to our 2” handle that contains the PCB board and all our electronics. For the slide mechanism to work we 3D printed spacers that had a wall thickness equal to the width of the gap created that would stop it from sliding all the way out or all the back through.

Final Design

Design Evaluation

The main issues with the old design that we set out to correct were the weight, the fact that it was wired, and that the data was not easily accessible in the field. Our final design fixed all these issues in an efficient and cost-effective way. Our final design is under 5lbs per probe, and they communicate with each other up to 1000 meters and then communicate their data through Bluetooth up to 100 meters. The data is then transferred to an easily accessible excel document through our app to someone’s mobile device. Other design requirements that needed to be solved were that they had to be durable and waterproof. Both of which are by using thick-walled PVC and sealing off everywhere water would have the ability to enter the circuitry. Overall, our system provides the USDA forest service with a new and improved method for data collection that allows for easy use and access to the data for the user.

Final Probe Assembly

Conclusions

Recommendations for future use:

- Have the circuitry be in a separate housing inside the handle. This would allow the circuitry to be more waterproof if the PVC handle were to crack, or any of the sealant were to break. This would also give the circuitry its own space, so it would not be bouncing around loosely in the handle. Finally, this would allow the circuitry to be more secure in the cap, as you would be able to use a different method to secure it in than just the 9V battery snaps that we used.
- Add a reel system for the excess wire. We believe that adding a spring-loaded reel system would fix the problems that we encountered while trying to design failed reel system. Having a working reel system would also make it so the user would never have to manually reel the wire in.
- Have the wires be more easily attachable/detachable from the circuit boards. In our design we have all the wires soldered directly onto the circuit board, and on several occasions the wires have broken off and needed to be resoldered on. Having screw locking wires would allow you to not only change the wires with ease, but also change the configuration of the wires if you wanted to change the code.

Features that did not make it into the design:

- Reel system – Because the wire was too thick it was not able to spool up without getting tangles and retracting the wrong side.

- Tripod – We decided not to go with this method because it left the probes to be too vulnerable in the stream. It made more sense for the user to hold the probe to take the reading.

Appendix

1.0 - Budget

1.1 - Full Budget

Capstone Project Budget Template - Fall/Spring

Project: Stream Measurement System

Last Updated 4/29/2021

Expense Items	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Item Total		
					Year						
Equipment/Tools:											
									$ -		
Travel:											
									$ -		
									$ -		
Supplies / Parts / Services:											
Electrical Components		$ 28.40	$ 19.69			$ 28.60	$ 77.51	$ 91.64	$ 245.84		
Materials		$ 28.42	$ 9.08		$ 38.35	$ 75.04	$ 11.37	$ 50.49	$ 212.75		
									$ -		
									$ -		
									$ -		
									$ -		
									$ -		
									$ -		
									$ -		**Expenses**
										$ 458.59	**Subtotal**
Time Spent (est. Hrs):									Hours		
Prototype Building	10	20		10	20	18	23	47	148		
Testing			25	10	19	20	29	30	133		
									0		
Shop Usage(est Hrs):							3	4	7		
									0		
									0		
								Graduate Student Support	$ -	**including fringe**	
								Shop Overhead	$ 400		
								University Overhead	$ 43	**5% of all expenses**	
								Totals	**$ 901.52**	**$ 1,500**	$ 598
										Budget	Excess

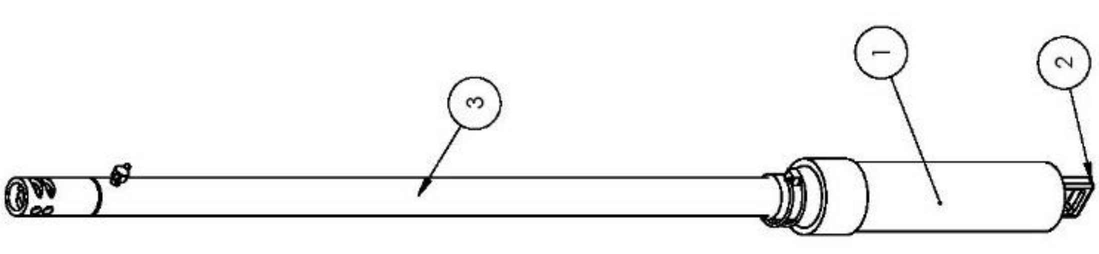
1.2 - Budget Breakdown

Item	Place of Purchase	Date	Cost
Analog TDS Sensor for Arduino, HM-10	Amazon	10/03/20	$ 28.40
2"x10' Conduit, 3/4"x5' White Plex, 1/2"x5' White Plex	MBS	10/23/20	$ 20.72
Reducer x1	Supplyhouse.com	10/23/20	$ 7.70
1/2"x10' White PVC, 1"x10' White PVC	MBS	11/05/20	$ 9.08
Batter Holders	Amazon	11/12/20	$ 8.04
Waterproof Plug	Amazon	11/12/20	$ 11.65
1/2"x10' Conduit, 1"x10' Conduit, Sealant, Plastic Glue, Fasteners	MBS	01/24/21	$ 38.35
Buttons	Amazon	02/17/21	$ 11.65
Electrical Wire	Amazon	02/17/21	$ 16.95
Reducer x3	PVC fitting online	02/17/21	$ 26.32
3D Printer Filament	Amazon	02/24/21	$ 24.37
Safety Coupler Pin x4, Hand Wrist Strap	Amazon	02/25/21	$ 24.35
Fasteners	MBS	03/05/21	$ 11.37
PCB parts	Digi-key	03/28/21	$ 39.94
PCB's	JLCPCB	03/29/21	$ 23.80
New Buttons	Amazon	03/30/21	$ 13.77
Batteries, LED lights, E-Z Lok Inserts	Amazon	04/01/21	$ 31.25
9V Battery Holder	Amazon	04/01/21	$ 9.53
Super Glue	Amazon	04/01/21	$ 8.00
Thumb Screws	Amazon	04/01/21	$ 18.02
1" x 10' SCH 80 Conduit	MBS	04/05/21	$ 14.49
Battery Snaps	Digi-key	04/13/21	$ 26.96
PCB's 2nd Prototype	JLCPCB	04/14/21	$ 23.90
Glue	Tri-State	04/29/21	$ 9.98
University Overhead (5% of all expenses)			$ 22.93
		Expenses Subtotal:	$ 458.59
		Total Cost:	$ 481.52

2.0 - Drawing Package

2.1 - Probe Housing Drawing Package

ITEM NO.	PART NUMBER	QTY.
1	01_00_Handle Assembly	1
2	03_00_Canister Assembly	1
3	02_00_Extension Assembly	1



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DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION

MATERIAL:

PROJECT NAME

DEFAULT TOLERANCES:
LINEAR: X.± .25 X.X± .1 X.XX± .01 X.XXX± .002
ANGULAR: X.± 2 X.X± 1 X.XX± 0 30'

DESCRIPTION:
CHECKED BY: DATE:
DRAWN BY: DATE: 5/5/2021
FILE NAME: 00_00_Main Assembly.SLDPRT

UNIVERSITY OF IDAHO
ME DEPARTMENT

PART #: QTY:
SCALE: 1:12 SHEET: 1 OF 13

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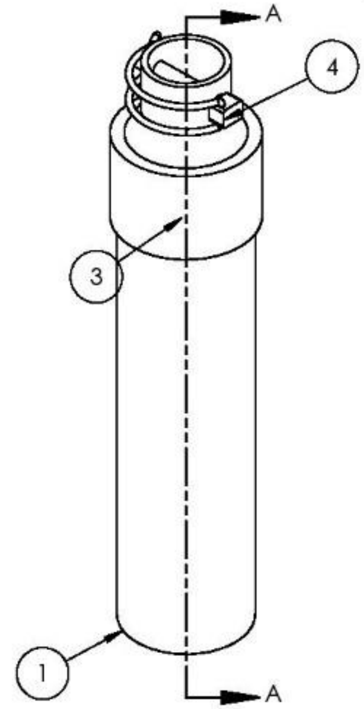
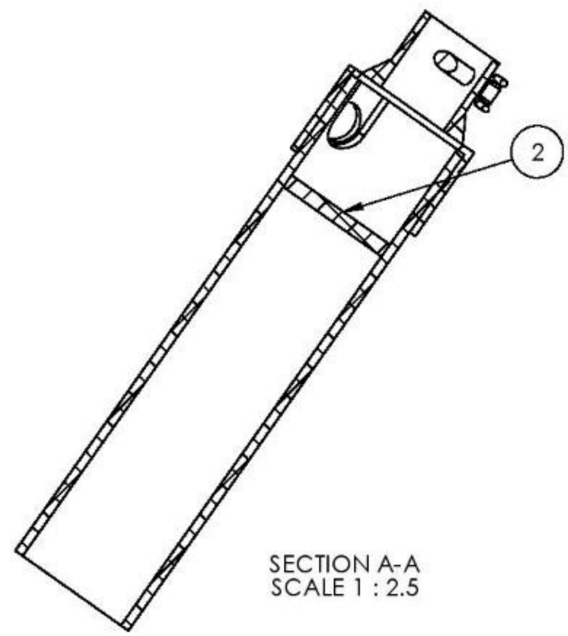
ITEM NO.	PartNo	DESCRIPTION	QTY.
1	01_01	2 Inch Conduit	1
2	01_02	Acrylic disk	1
3	01_03	Reducer	1
4	90978A400	Purchased Part: Safety coupler pin	1





SECTION A-A
SCALE 1 : 2.5

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DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION

PROJECT NAME

DEFAULT TOLERANCES:
LINEAR:
ANGULAR:

DESCRIPTION: Handle Assembly

UNIVERSITY OF IDAHO ME DEPARTMENT

DATE: 5/5/2021
PART #: 01_00
FILE NAME: 01_00_Handle Assembly.SLDPRT
SCALE: 1:12
SHEET: 2 OF 13

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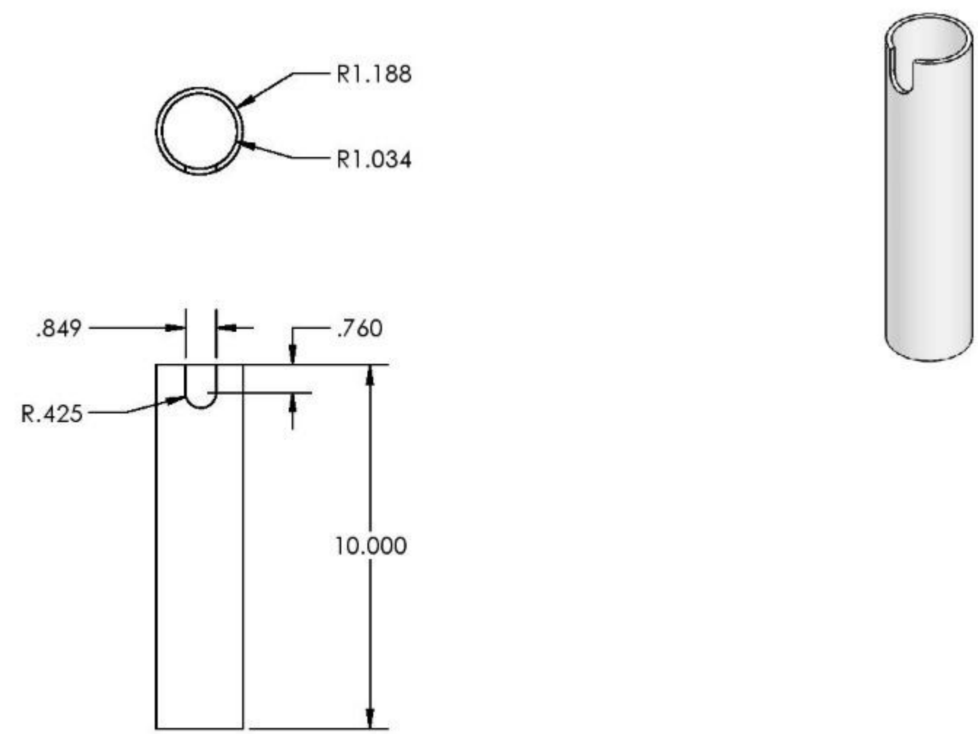

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DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION

MATERIAL:

DEFAULT TOLERANCES:
LINEAR: X ± .25, X.X ± .1, X.XX ± .01, X.XXX ± .002
ANGULAR: X ± 2, X.X ± 1, X.XX ± 0 30'

DESCRIPTION:
CHECKED BY: DATE:
DRAWN BY: DATE: 5/5/2021
FILE NAME: 00_00_Main Assembly.SLDPRT

UNIVERSITY OF IDAHO
ME DEPARTMENT

PART #: QTY:
SCALE: 1:4 SHEET: 3 OF 13

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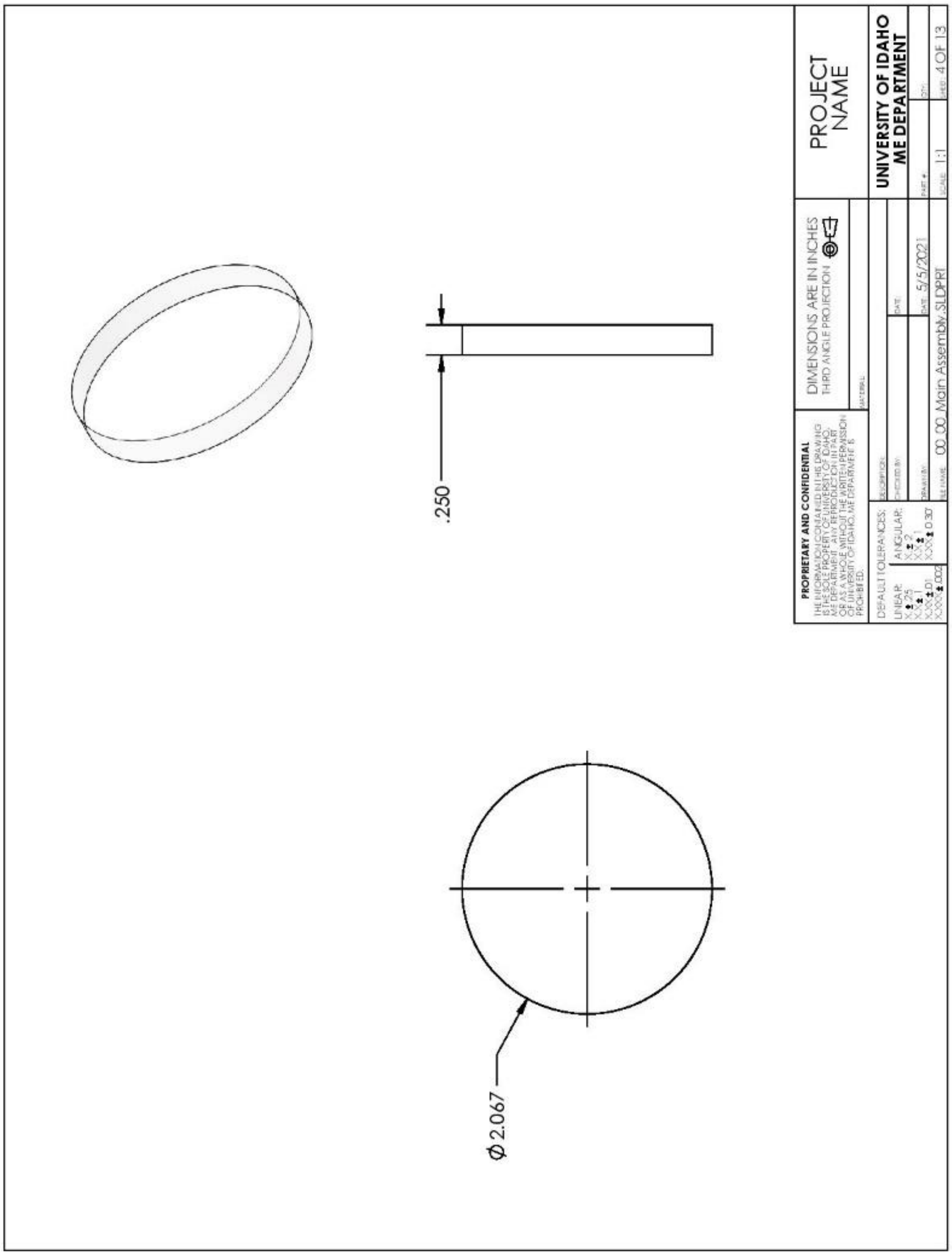

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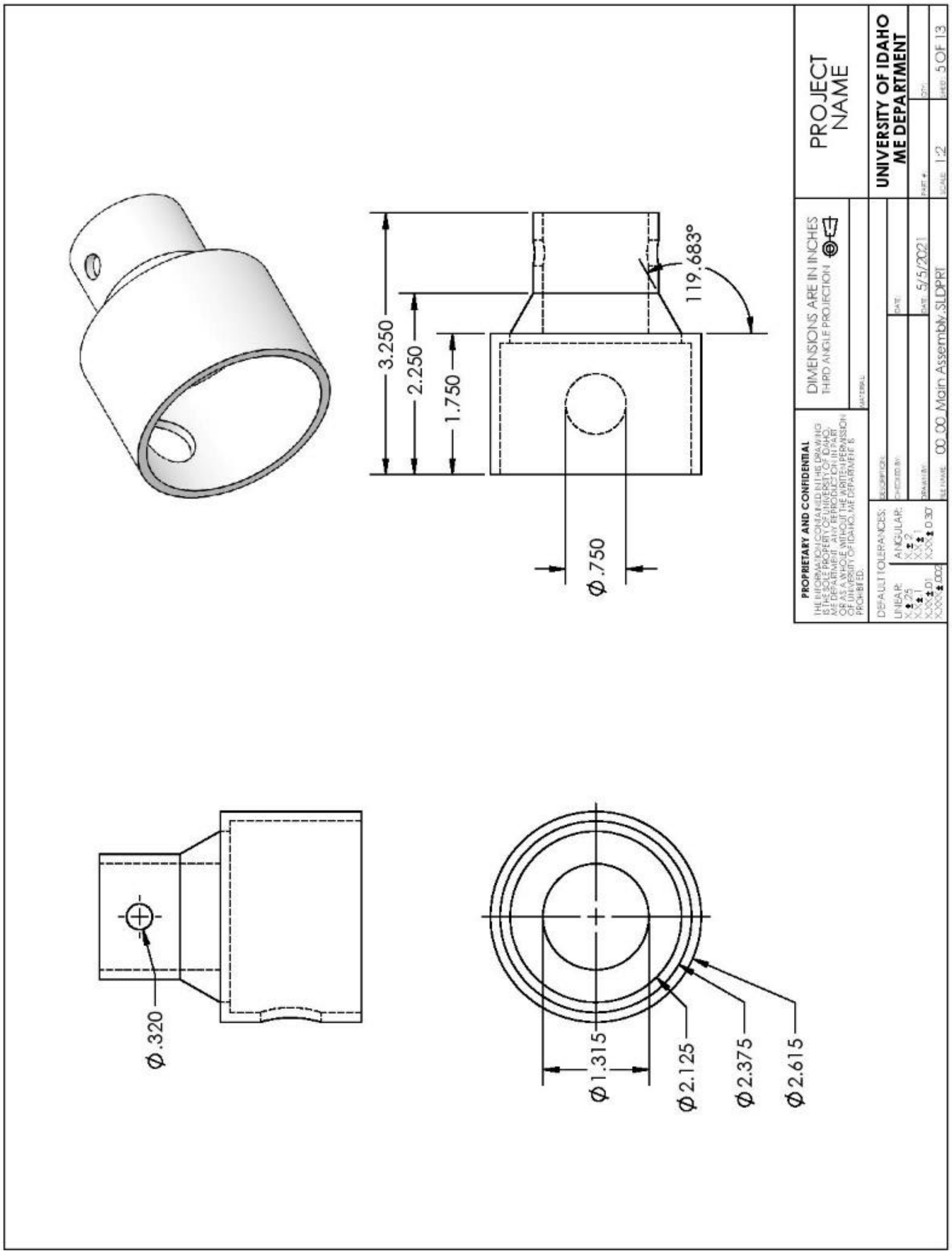
PROPRIETARY AND CONFIDENTIAL
DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION
PROJECT NAME
UNIVERSITY OF IDAHO
ME DEPARTMENT
DEFAULT TOLERANCES:
LINEAR:
ANGULAR:
DATE: 5/5/2021
00 00 Main Assembly.SLDPRT
SCALE: 1:1
SHEET 4 OF 13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1.750
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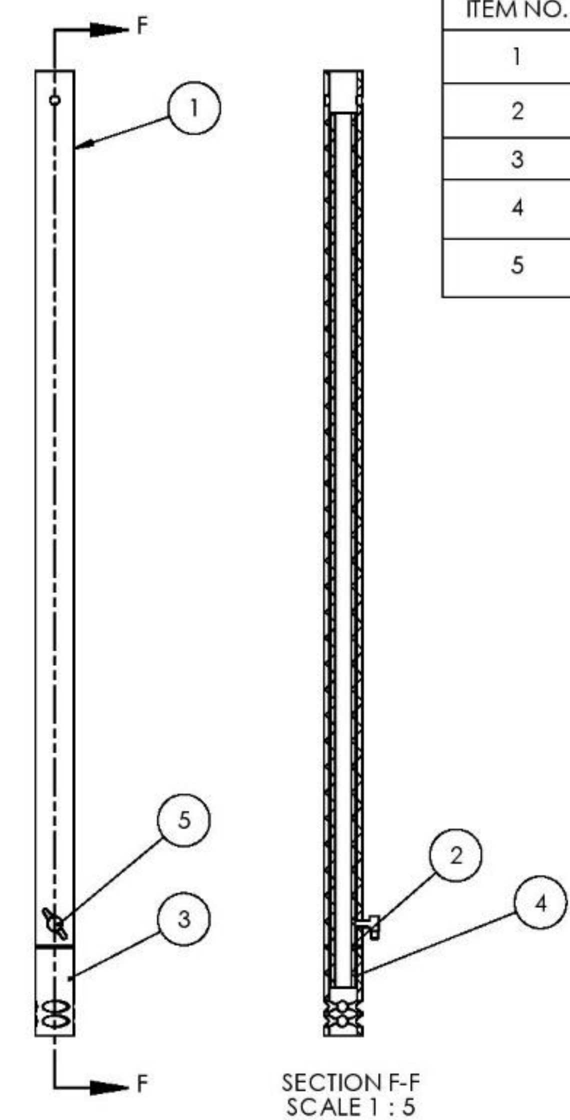
PROPRIETARY AND CONFIDENTIAL
DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION
DEFAULT TOLERANCES:
LINEAR:
ANGULAR:
DATE: 5/5/2021
00_00_Main Assembly.SLDPRT
PROJECT NAME
UNIVERSITY OF IDAHO
ME DEPARTMENT
SCALE: 1:2
SHEET 5 OF 13



ITEM NO.	PartNo	DESCRIPTION	QTY.
1	02_02	1 inch conduit	1
2	02_01	1/2 inch conduit	1
3	02_03	Probe cover	1
4	02_04	Shim for probe cover	1
5	91185A917	Purchased Part: Plastic head wing bolt	1

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DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION

MATERIAL:

PROJECT NAME

DEFAULT TOLERANCES:
LINEAR: X ± .25, XX ± .1, XXX ± .01, XXXX ± .002
ANGULAR: X ± 2, XX ± 1, XXX ± 0 30'

DESCRIPTION: Extension Assembly
CHECKED BY: DATE:
DRAWN BY: DATE: 5/5/2021
FILE NAME: 02_00_Extension Assembly.SLDPRT

UNIVERSITY OF IDAHO ME DEPARTMENT
PART #: 02_00 QTY:
SCALE: 1:12 SHEET: 6 OF 13

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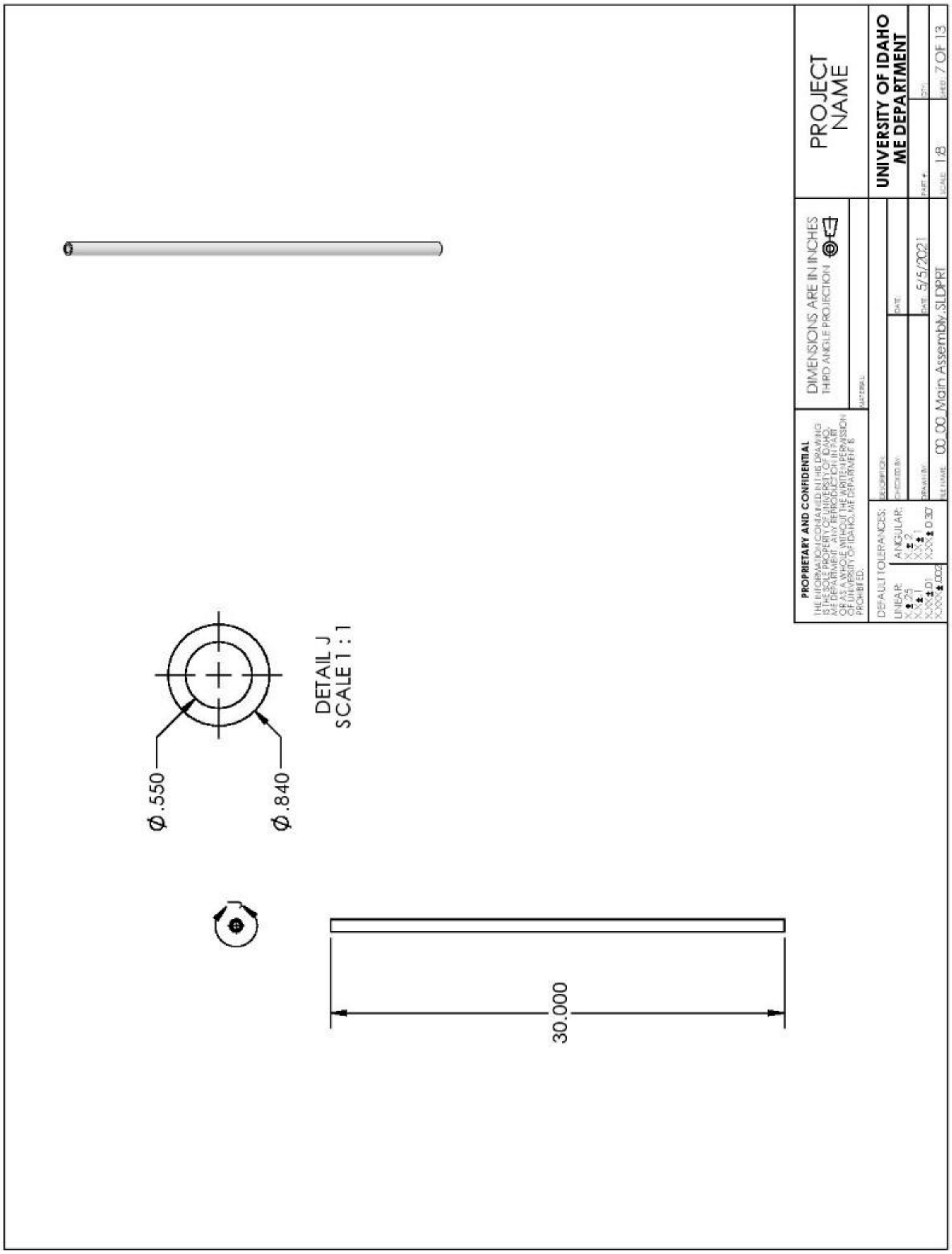

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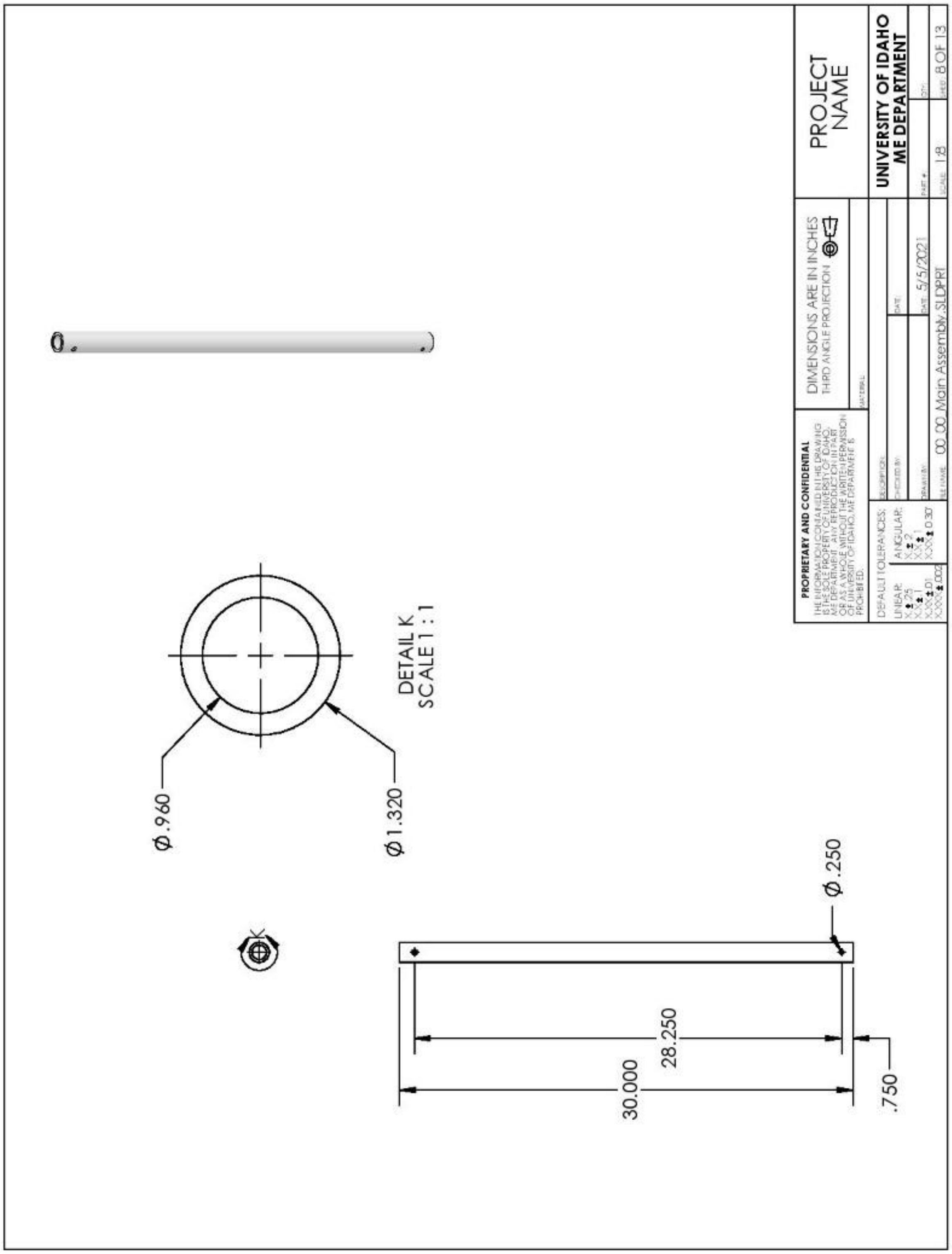

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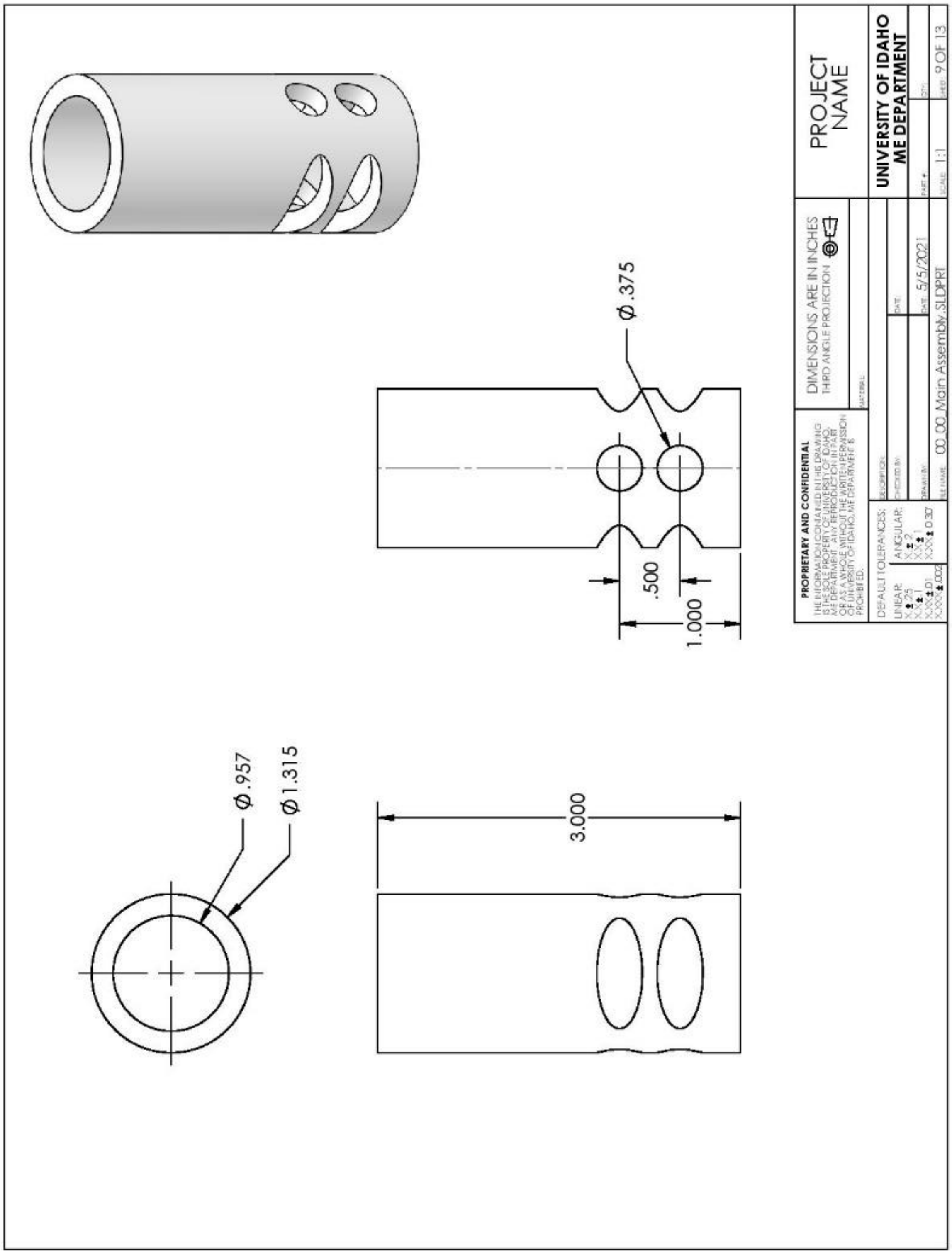

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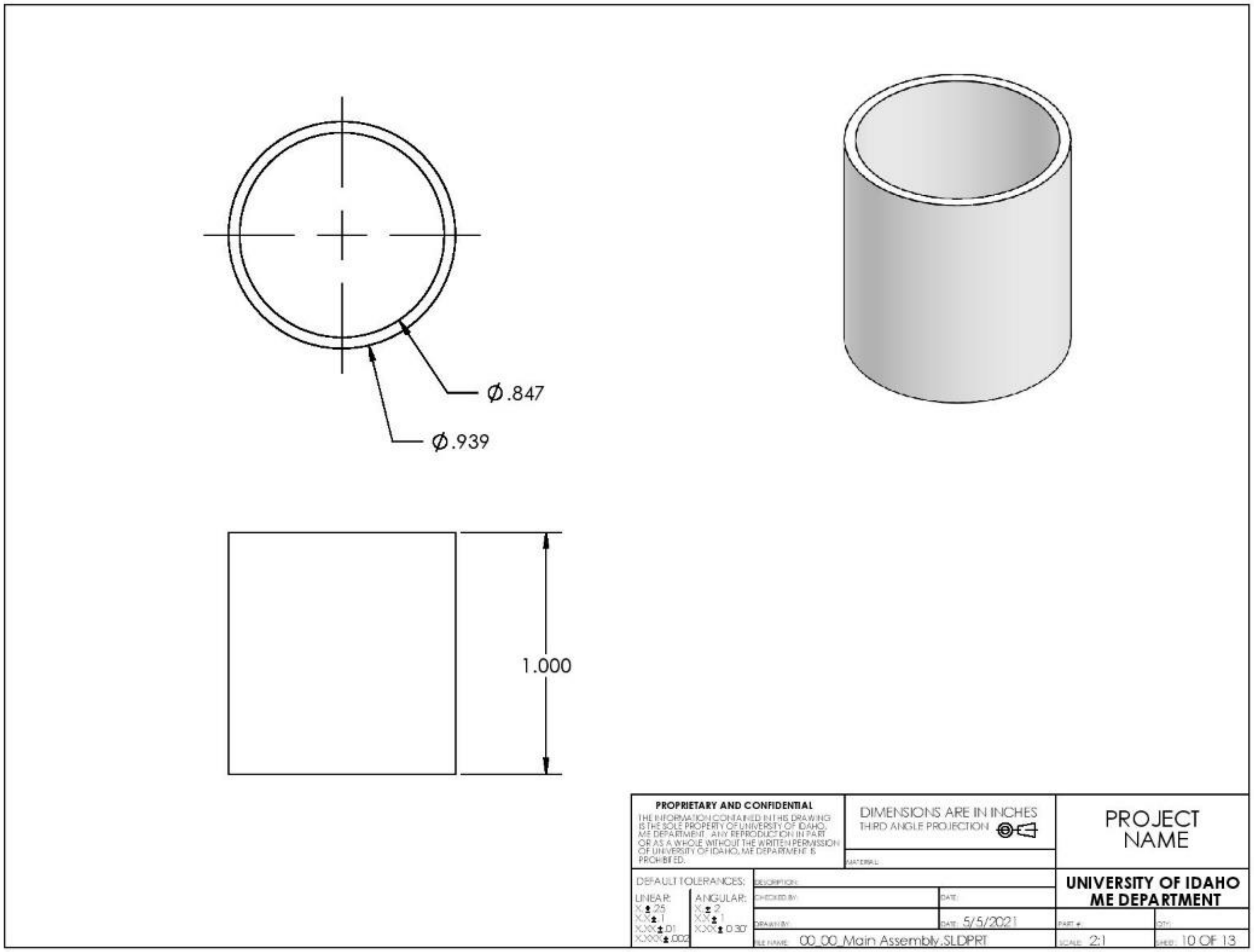

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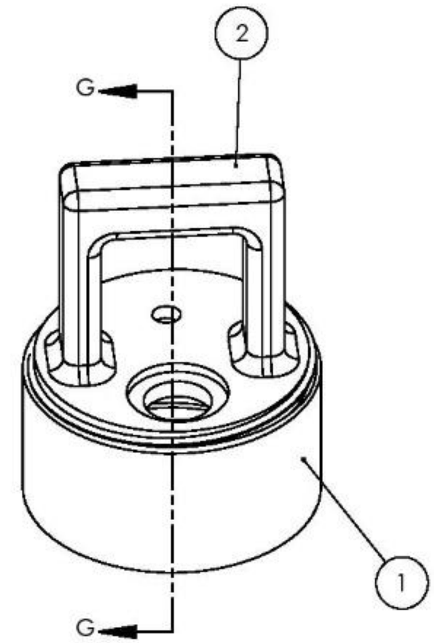
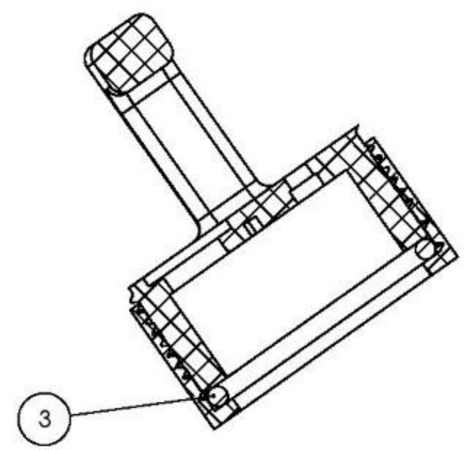
ITEM NO.	PartNo	DESCRIPTION	QTY.
1	03_01	Electrical canister/cap insert	1
2	03_02	Electrical Canister/cap	1
3	9452K610_OIL-RESISTANT BUNA-N MULTIPURPOSE O-RING	O-Ring	1





SECTION G-G
SCALE 1 : 1

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DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION

MATERIAL:

PROJECT NAME

DEFAULT TOLERANCES:
LINEAR: X.±.25 X.X±.1 X.XX±.01 X.XXX±.002
ANGULAR: X.±2 X.X±1 X.XX±0.30'

DESCRIPTION: Canister/Cap Assembly
CHECKED BY: DATE:
DRAWN BY: DATE: 5/5/2021
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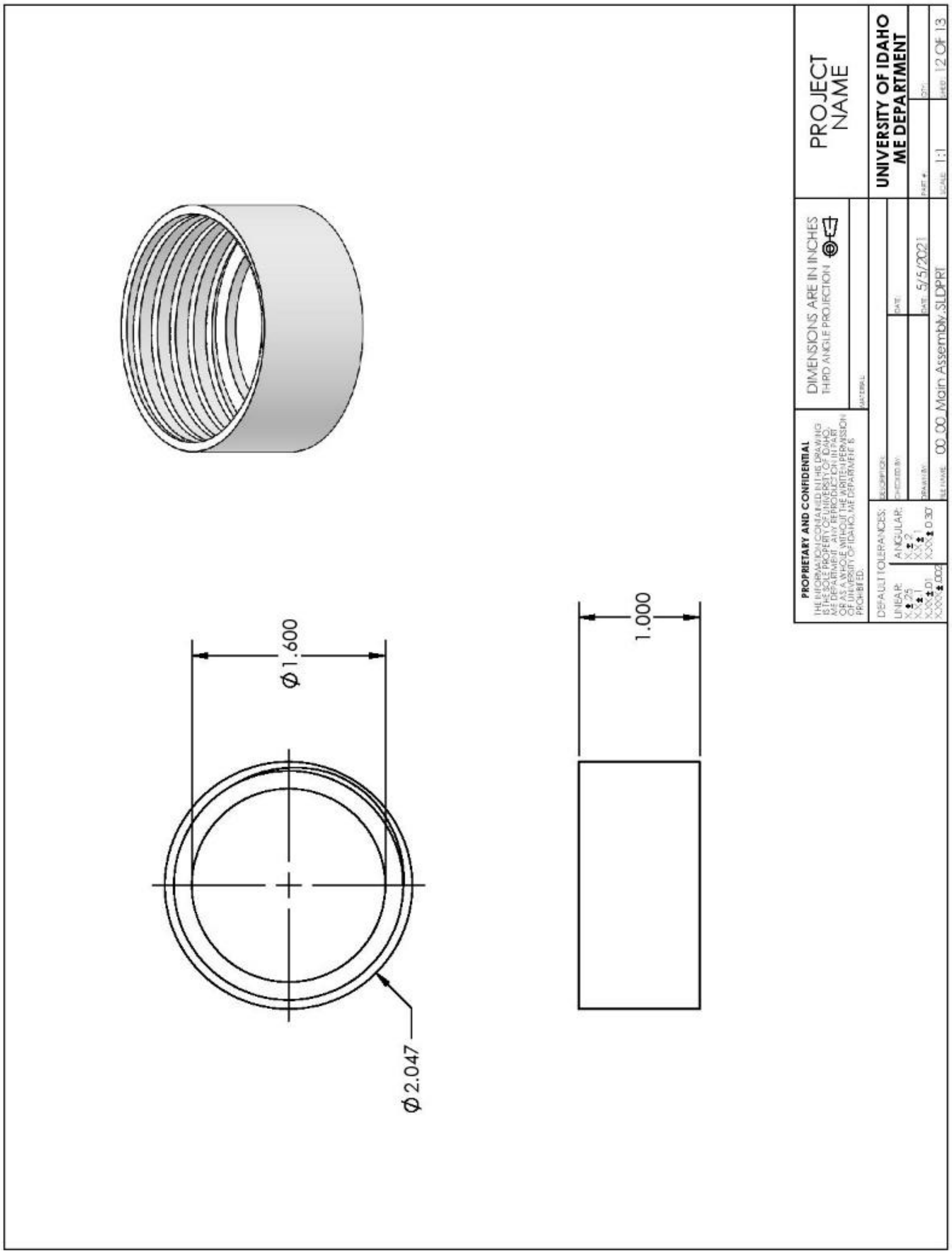
UNIVERSITY OF IDAHO
ME DEPARTMENT
PART #: 03_00 QTY:
SCALE: 1:12 SHEET: 11 OF 13



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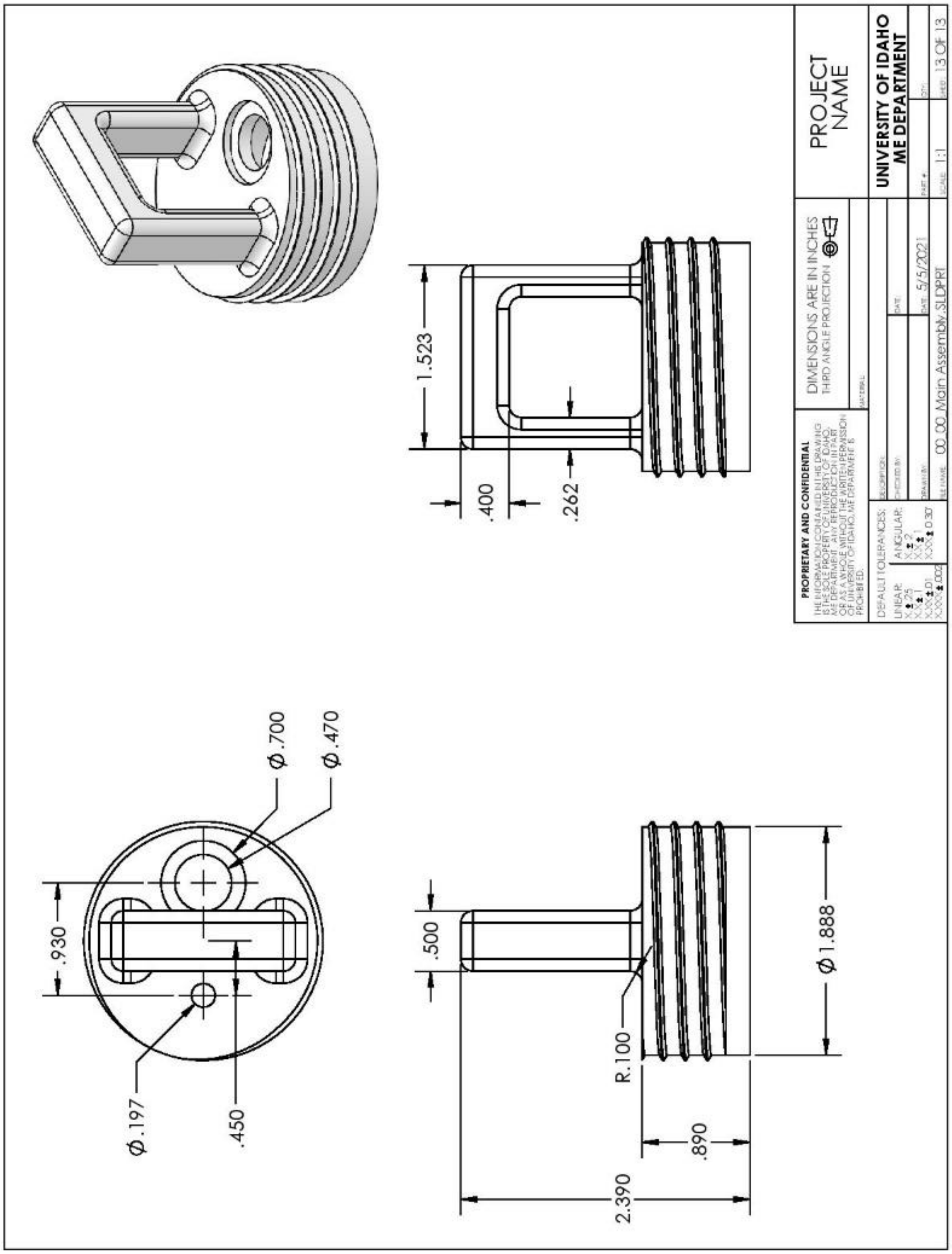

Ø.197
.450
.930
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Ø.470
2.390
.890
R.100
Ø1.888
.500
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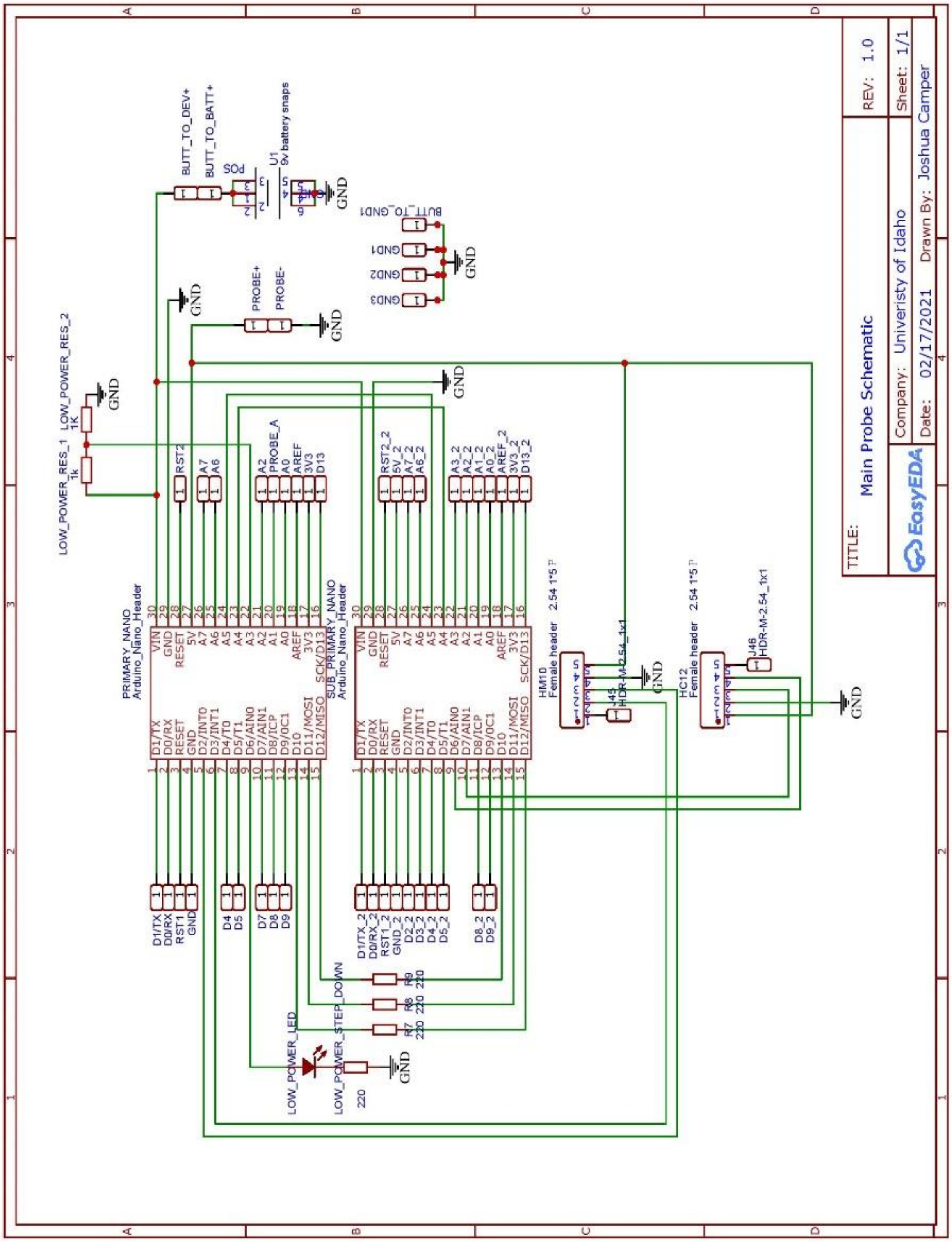
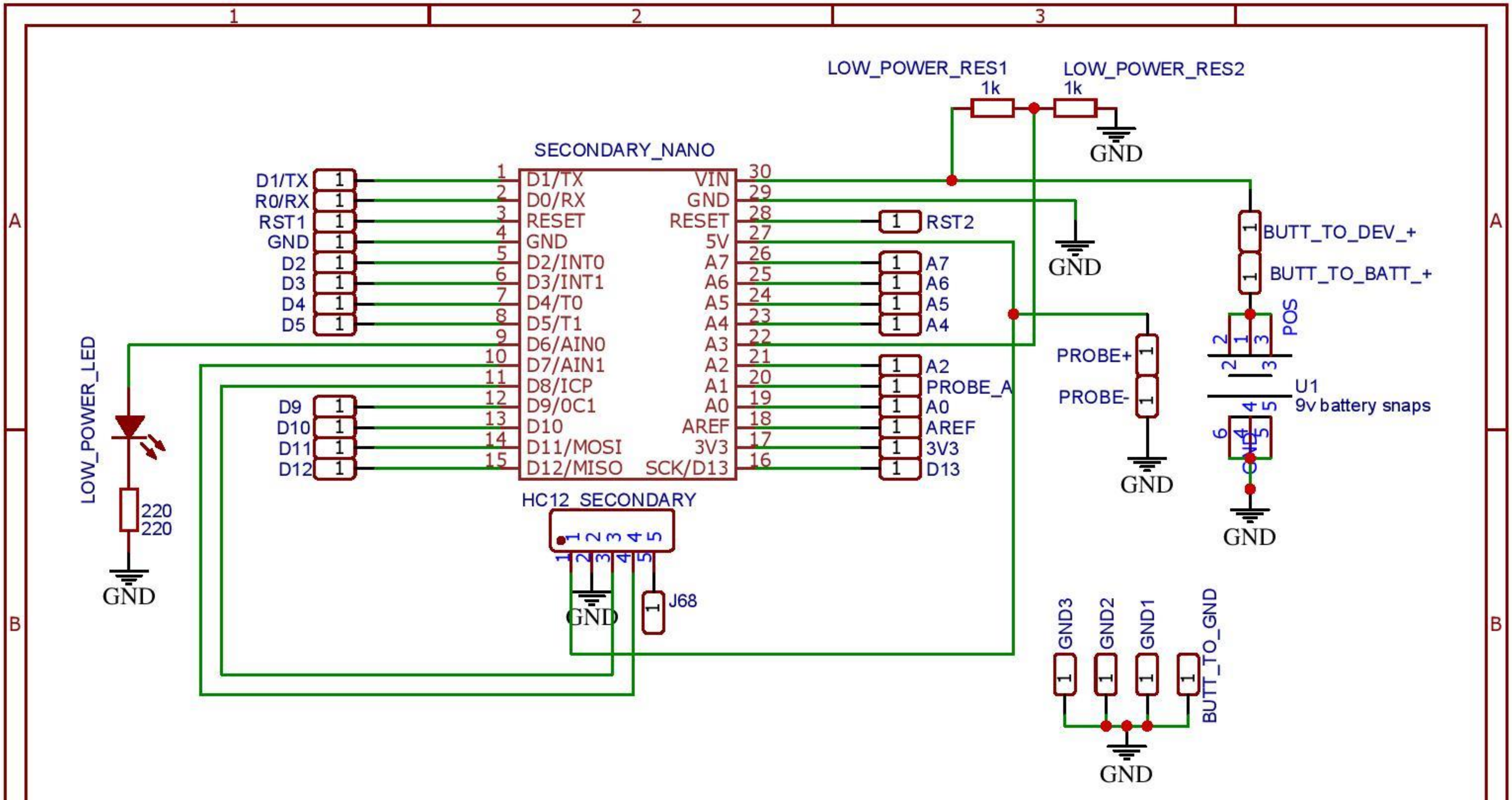
.262
1.523
PROPRIETARY AND CONFIDENTIAL
DIMENSIONS ARE IN INCHES
THIRD ANGLE PROJECTION
PROJECT NAME
DEFAULT TOLERANCES:
LINEAR: X ± .25 XX ± .1 XXX ± .01 XXXX ± .002
ANGULAR: X ± 2 XX ± 1 XXX ± 0 30'
DATE: 5/5/2021
00_00_Main Assembly.SLDPRT
UNIVERSITY OF IDAHO
ME DEPARTMENT
SCALE: 1:1
SHEET 13 OF 13

2.2 - PCB Drawing Package





TITLE: Secondary Probe Schematic		REV: 1.0
EasyEDA	Company: University of Idaho	Sheet: 1/1
	Date: 03/09/2021 Drawn By: Joshua Camper	

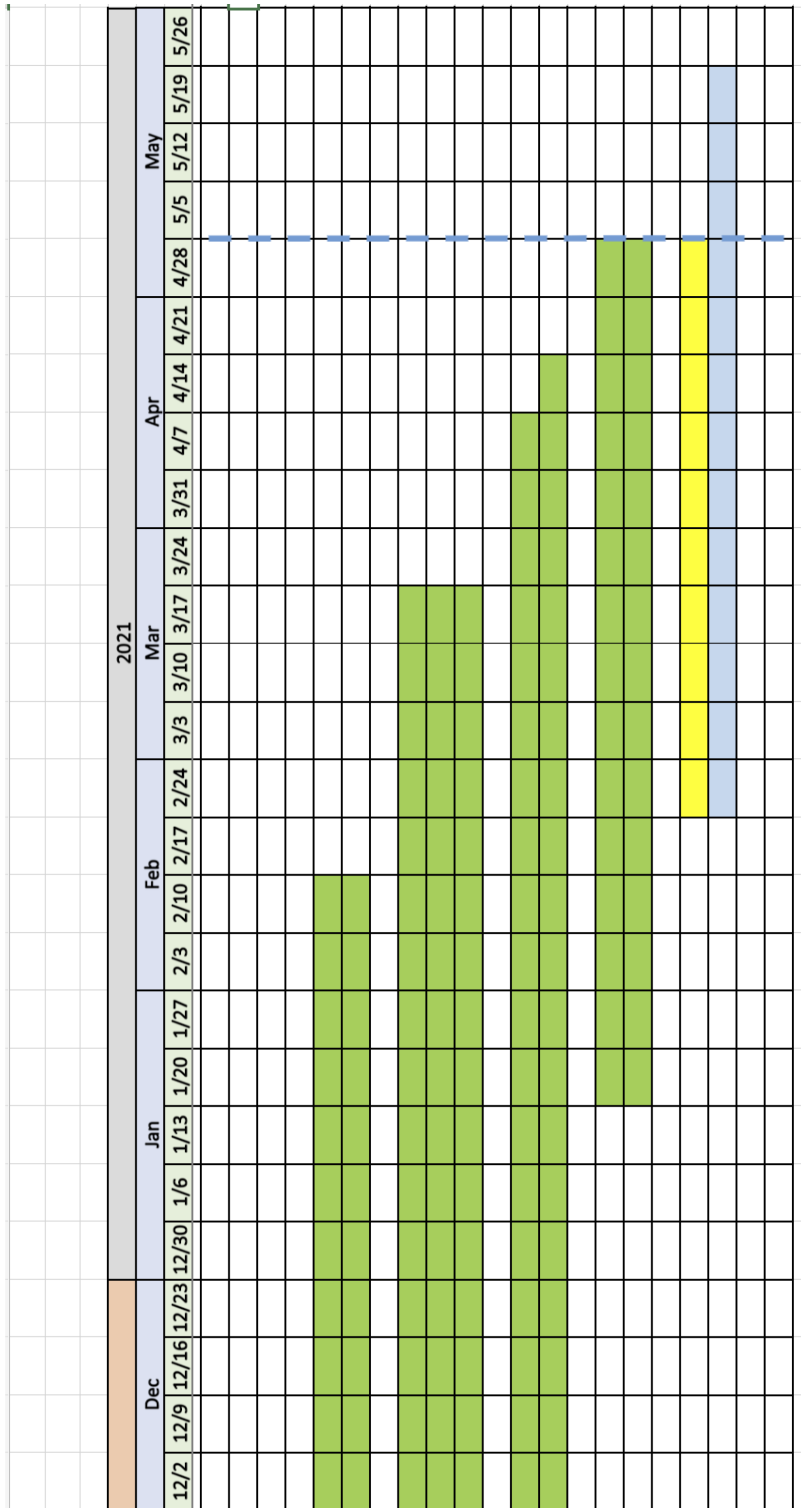
3.0 - Schedule

Capstone Project Schedule Template - Fall-Spring

Project: **USDA Foreset Service - Steam Velocity Measurment Device**

Last Updated: 4/29/21

Category	Task Description	Duration	Assigned	9/2	9/9	9/16	9/23	9/30	10/7	10/14	10/21	10/28	11/4	11/11	11/18	11/25
			Year	2020												
			Month	Sept				Oct					Nov			
Main 1	**Make sure probes read concentration and communicate between them**															
Sub 1.1	Set up a way to read the signal from a device		EE	■	■	■										
Sub 1.2	Test probes with the salt solution and the device that reads the signal		EE	■	■	■	■									
Main 2	**Waterproofed components (housing)**															
Sub 2.1	Design sketches/drawings/3D models		ME					■	■	■	■	■	■	■	■	■
Sub 2.2	Prototype designs		ME							■	■	■	■	■	■	■
Main 3	**Make app to read data**															
Sub 3.1	Get app to read data from probes		EE			■	■	■	■	■	■	■	■	■	■	■
Sub 3.2	Get app to make calculations that are desired by client		EE			■	■	■	■	■	■	■	■	■	■	■
Sub 3.3	Get app to make graphs that are desired by client		EE			■	■	■	■	■	■	■	■	■	■	■
Main 4	**One system that we can use to set housing for all stream sizes**															
Sub 4.1	Design sketches/drawings/3D models		ME				■	■	■	■	■	■	■	■	■	■
Sub 4.2	Prototype designs		ME							■	■	■	■	■	■	■
Main 5	**Lab tested "working" version**															
Sub 5.1	Combine waterproof housing with the system design		ME/EE													
Sub 5.2	Test everything combined in a small stream		ME/EE													
Main 6	**Test real world in spring**															
Sub 6.1	Test everything combined in a bigger stream outdoors		ME/EE													
Sub 6.2	Client Testing		ME/EE													


2021
Dec
Jan
Feb
Mar
Apr
May
12/2
12/9
12/16
12/23
12/30
1/6
1/13
1/20
1/27
2/3
2/10
2/17
2/24
3/3
3/10
3/17
3/24
3/31
4/7
4/14
4/21
4/28
5/5
5/12
5/19
5/26

4.0 - Design Validation

Senior Capstone Design

Project: USDA - Stream Velocity **Primary Author:** Max Rietze

Team: Stream Team **Date:** 4/29/2021

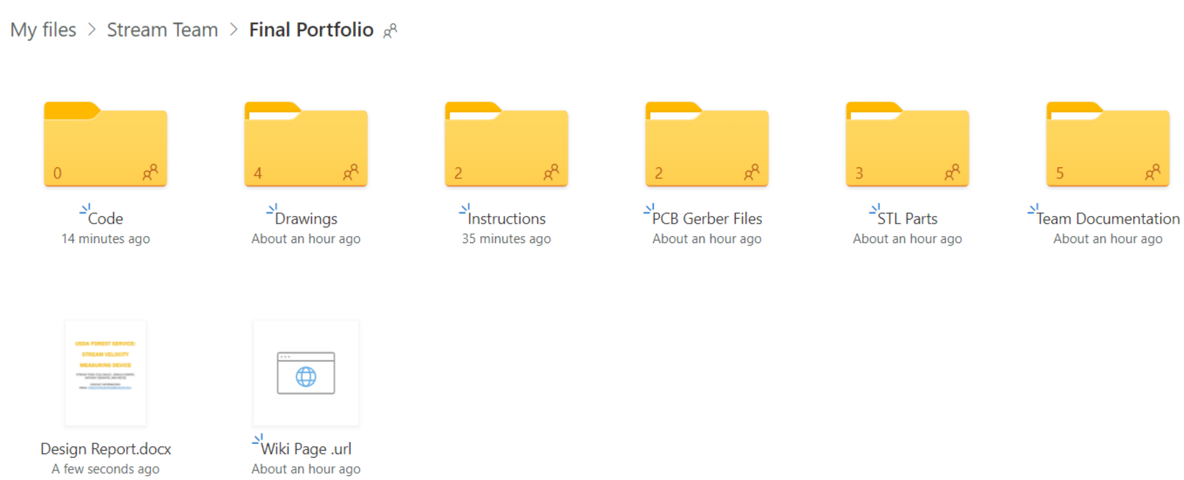
Design Validation Plan & Results (DVP&R)

Requirement	Test	Test Subject	Target Date	Result	Recommendation
Probes communicate 100ft away	separate probes by 100ft and test for communication	HC 12 wireless transmitter	10/28/20	Successful Test the probes comunicated	
Probes communicate 100ft away with interferance	separate probes by 100ft and test for communication with pipe wall inbetween	HC 12 wireless transmitter	10/28/20	Material interferance didnt seem to be an issue with communication	
Probes communicate 100ft away	separate probes by 100ft and test for communication	HM 10 (bluetooth) wireless transmitter	11/4/20	Successful Test the probes comunicated	
Probes communicate 100ft away with interferance	separate probes by 100ft and test for communication with pipe wall inbetween	HM 10 (bluetooth) wireless transmitter	11/4/20	Material interferance didnt seem to be an issue with communication	
Pipe is water proof when caps are on.	pour water over tube and ends then dry off and check for internal moisture	Probe container	4/17/21	Water was able to seep through the threading on the 3D printed cap	Add an O-ring to not let the water into the housing
circuit casing is water proof	pour water into the outter tube and make sure no water enters the secondary container	inner circuit container and outter pipe	2/17/21	N/A. We removed the secondary container from the design	
batter life is at least 10hrs in duration	run the system with a timer and periodically check if it has died up to 10 hrs	battery pack	2/17/21	The probes were able to send data continuously overnight with no problems	
the outter pipe must be durable	apply force to outter tube and check for cracking or substantial damage	device handle and container	11/11/20	The PVC should be able to with stand the stresses that it will be put under	
system is capable of transitioning to small stream form	the probe is easily detachable from main handle and easily attachable small stream flag	probe and clips	2/17/21	The extendable handle is removable, which makes for an easy transition to small streams	
data is accurate and reads with a high enough resolution	run old system and new system to compare data	probes	11/11/20	The data ligned up with the old systems and was reading accurately	
probes read simultaionly	insert probes into water and have them communicate their data at the same time	probes and circuit	10/28/20	The probes output simultaioniously	
Retractable wire	try to retract wire with reel system	reel system	4/26/2021	Wire tangled, not succesful	Try draging the wire vs. winding it up

5.0 - Vendor Data Sheets

Parts	Location/ Online Store	Part Number (If applicable)
Conduit (.5",1",2") Sch 80	MBS/Tristate (Hardware Store)	
EZ Lock Threaded Inserts	MBS/Tristate (Hardware Store)	
Thumb Screw	MBS/Tristate (Hardware Store)	
Loctite Super Glue	MBS/Tristate (Hardware Store)	510-834
Water Proof Sealant	MBS/Tristate (Hardware Store)	3700-0197
2" - 1" Reducer Sch 40	PVC Fitting	
Electrical Wire	Amazon	Amazon Link
Wrist Strap (9.5 Inch)	Amazon	Amazon Link
Water Proof Clips	Amazon	Amazon Link
HM-10	Amazon	Amazon Link
HC-12	Amazon	Amazon Link
Button	Amazon	Amazon Link
Arduino Nano	Amazon	Amazon Link
5mm LED (red)	Amazon	Amazon Link
resisrors (1k Ohm)	Amazon	Amazon Link
resistors (220 Ohm)	Amazon	Amazon Link
Safety Coupler Pins	Amazon	Amazon Link
Battery Contact Snap 9V Male	Digi Key	36-593-ND
Battery Contact Snap 9V Female	Digi Key	36-594-ND
1x15 pin header	Digi Key	S7013-ND
1x5 pin header	Digi Key	S6103-ND
TDS Probe	Digi Key	1738-1368-ND
Circuit Boards	JLC PCB	

6.0 - Overview of Shared Drive Folder



7.0 - Instructions

7.1-Assembly Instructions

1. Cut all PVC to length (Reference Appendix 2.1 as needed)
    a. 2” conduit – one that is 13” (main probe) and another that is 10” (secondary probe)
    b. 1” conduit – 2 x 3’
    c. ½” conduit – 2 x 3’
    d. Probe cover – 2 x 4”
2. 3D Print all necessary parts
    a. 2 x Canister
    b. 2 x Canister Insert
    c. 6 x Shims
3. Drill holes through the probe cover
4. Drill hole for coupler pin through 1” side of the reducer and 1” conduit
5. Drill hole in the acrylic disk for probe connection wire
6. Place lead wire for waterproof clip through the drilled hole
7. Solder the lead to the female end of the waterproof clip that is as long as the 2” conduit piece
8. Solder button and LED leads
9. Super glue parts together:
    a. The canister insert to the inside at the end of the 2” conduit
    b. The acrylic disk to the inside of the other end of the 2” conduit
    c. A shim to the inside of the 1” conduit
    d. A shim to the outside of the ½” conduit
    e. The button and LED into the canister
10. Seal components:
    a. Around the acrylic disk and wire hole
    b. Around the button and LED holes
11. Slide the ½” PVC into the 1” PVC on the side that does not have the shim on it
    a. Super glue the 3rd shim to the ½” conduit end that does not already have one
        i. Now the ½” conduit should not be able to slide out of the 1” conduit (shims are glued on either end)
12. Glue the Velcro on the inside of the ½” conduit that is sticking out of the 1” conduit
13. Glue the Velcro onto the probe wire under the actual probe head
14. Glue the probe cover onto the end of the ½” conduit that is sticking out of the 1” conduit
    a. Should be glued onto the shim and sit flush with the 1” conduit when collapsed
15. Cut slot into the 2” conduit end that has the acrylic disk
16. Drill hole into the 2” side of the reducer
17. Solder one end of the 6’ wire to a male end of a waterproof clip and the other end to a probe
18. Solder all PCB components to designated areas according to the PCB board and drawing schematic

7.2- Electronics and App Instruction Manual

- Found in Instructions File.